Can Educational Attainment Explain Total Factor Productivity? Growth Accounting Evidence from Seven Transition Countries for the Period 1991-2000*

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Abstract

In this paper we use growth accounting methodology to study whether human capital explains a part of total factor productivity in transition. The results that are obtained are not in support of the theoretical findings of growth theory that human capital is a major determinant of growth and productivity. However, eventually we continue to believe that the reasons for this misfit to theory lie in the very nature of data and not in the specifics of the methodology used.

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Contents

1 Introduction

It is widely accepted in growth theory that human capital is one of the major determinants of economic growth. In many works it is attributed an importance that at least matches the importance of the 'traditional' factors, labor and physical capital, and sometimes it is even attributed the highest importance. One of the most remarkable examples of research work defending this statement and which has received high attention is Mankiw, Romer and Weil (1992). In this paper the authors argue that the Solow model is a plausible explanation of growth and convergence across nations when it is augmented with a measure of human capital. They find a contribution of human capital to growth of about 1/3 on average. Lucas (1988) is another widely cited article, which justifies the presence of human capital in growth models; he claims that human capital does not improve the ability of the Solow model to fit the data, but presents a broader range of possibilities to account for the income and growth differentials among countries. Other well-known examples of treating human capital as an important growth factor in a similar fassion are e.g. Becker, Murphy and Tamura (1990) or Rebelo (1991).

In the current paper we use a deterministic modeling framework, with the help of which analysis of the contribution of human capital to growth in seven transition countries has been made. Also, calculations have been performed to show whether the unadjusted-for-human-capital Solow residual, which is frequently used as a measure ot technological development, is affected by the accumulation of human capital.

In this study we consider seven countries in transition to market economy. Five of them have already joined the European Union in 2004: the Czech Republic, Hungary, Poland, Slovenia, and Slovakia. The remaining two countries are Bulgaria and Romania, which are about to join the European Union (hopefully)

on January 1, 2007. We investigate the educational attainment of the employed persons in these countries and try to answer the question whether the data support the alleged importance of human capital for growth.

2 The analytical framework

To analyze the contribution of human capital to GDP growth, respectively to total factor productivity, two complementary frameworks will be considered. The first one is the standard growth accounting framework, originally used by Solow (1957), which decomposes output growth into contributions from physical capital and labor and attributes the remaining variation to a residual incorporating in general the contribution of technological development:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + a(t) \cdot \frac{\dot{K}(t)}{K(t)} + b(t) \cdot \frac{\dot{L}(t)}{L(t)}, \tag{1}$$

where Y is output, K is physical capital, L is labor, and A is the level of technology. The equation assumes that the marginal costs of capital and labor equal their respective prices, so that a and b are the corresponding factor shares in total income.

The second accounting framework resembles the one used by Hall and Jones (1999), in which an explicit inclusion of the human capital stock in the production function is considered:[1]

$$Y(t) = A(t) \cdot F(K(t), H(t)), \tag{2}$$

[1]To be precise, Hall and Jones use a Cobb-Douglas specification of the production function. Here we will only assume that it satisfies the neoclassical assumptions. Also, we assume Hicks-neutral instead of labor-augmenting technology in order to facilitate comparison.

where H is the human capital stock and:

$$H(t) = e^{\phi(E)} L(t) \tag{3}$$

Here $\phi(E)$ is a measure of the efficiency of a labor unit (a worker) that has undergone through E years of schooling. More specifically, since $\phi(0)$ is zero, with no years of schooling the respective labor unit's human capital merely coincides with its raw (unadjusted for human capital) inputs in production.

Assuming as usual that the factors of production are paid their marginal products, the accounting framework becomes:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + a(t) \cdot \frac{\dot{K}(t)}{K(t)} + b(t) \cdot \frac{\dot{H}(t)}{H(t)}, \tag{4}$$

One would be tempted to differentiate equation (4) with respect to time:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + a(t) \cdot \frac{\dot{K}(t)}{K(t)} + b(t) \cdot \left(\frac{\dot{L}(t)}{L(t)} + \dot{\phi}(E) \right), \tag{5}$$

make use of equation (3) and by observing that $\dot{\phi}(E) = 0$ claim that equations (1) and (4) actually are one and the same thing. It will become evident from the considerations below that the structure displayed in (3) is a bit more complex and $H(t)$ is a function of time through a couple more factors. The latter, however, does not preclude the existence of a partial case where the two equations are identical to each other.

3 Data considerations

The data that have been used are mainly from two sources. The first one is Eurostat,[2] and the data used from there is in general national accounting data (gross domestic product, gross fixed capital formation, labor's share, etc.; the respective source of the variables will be mentioned in the course of the presentation). The second source consists of results on educational attainment obtained by Barro and Lee (2000).

Some of the data are not readily available, but can be computed using what is already at hand. More specifically, the physical capital stock data can be constructed from the investment (gross fixed capital formation) series. Also, data on educational attainment are not available for the entire range of years, and the missing data points are computed additionally. Details on computations follow in the next subsections.

3.1 Physical capital stock

As already mentioned, the physical capital stock is calculated using the investment data available. The data for each country are taken at 1995 prices and in national currencies.[3] The initial capital stock is calculated in the same way as in Ganev (2005), i.e. $K_0 = I_0/\delta$, where δ is the annual capital stock depreciation rate.[4] (The initial capital stock for each country is calculated for the first year, for which

[2] More precisely, the Ameco database, available at http://europa.eu.int/comm/economy_finance/indicators/annual_macro_economic_database/ameco_en.htm.

[3] All other data concerning indicators of value (e.g. GDP) will be used in the same manner.

[4] In general, the formula $K_0 = I_0/(\delta + g)$ is used, where g is some average measure of investment growth. In many studies it is taken as a geometric mean of investment growth rates for the period under consideration. However, for some of the transition economies this average rate after 1990 is very high. Using it in the denominator would lead to a substantial underestimation of the initial physical capital stock. Unfortunately, data for earlier periods were not available to the author, and that is why this 'impreciseness' has been adopted in the calculations. However, the farther we are from the initial date, the weaker the influence of the initial physical capital stock on the results.

gross fixed capital formation data is available.) A value of $\delta = 0.05$ is used. The following data items for the physical capital stock are calculated using the permanent inventory method with geometric depreciation, i.e.:

$$K_t = I_t + (1 - \delta) \cdot K_{t-1} \tag{6}$$

The calculations concerning the physical capital stock are presented in Table 1 in Appendix A.

3.2 Human-capital-augmented employment

The figures are computed using the relation displayed in equation (3). As a measure of $L(t)$ the annual employment series is used. For the Mincerian coefficients we use the values estimated by Psacharopoulos and referred by Hall and Jones (1999), i.e.:

$$\phi(E) = \begin{cases} 0.134 \cdot E, \text{ if } E \leq 4; \\ 0.134 \cdot 4 + 0.101 \cdot (E - 4), \text{ if } 4 < E \leq 8; \\ 0.134 \cdot 4 + 0.101 \cdot 4 + 0.068 \cdot (E - 8), \text{ if } E > 8 \end{cases}$$

The data available from Barro and Lee (2000)[5] do not display the population by exact number of schooling years. Instead, the authors have presented the population of age 15 or more distributed across seven categories of educational attainment: no schooling, incomplete first level (primary) education, completed first level (primary) education, incomplete second level (secondary) education, completed second level (secondary) education, incomplete post-secondary (tertiary) education, and completed post-secondary (tertiary) education. As already men-

[5]The data set is available from http://www.cid.harvard.edu/ciddata/ciddata.html.

tioned, the exact number of schooling years is unavailable, and that is why we will make the following assumptions. We will assume that the people who have not completed a certain level of education, although they are enrolled and listed in the total number of persons in the respective educational level, remain with the same productivity gains as those in the lower completed level. For example, a person who has not completed the respective degree is as productive as a person having completed the one-level-lower degree. Although this assumption may look somewhat restrictive, it is quite reasonable since not completing an educational level often means that the person is a 'drop-out', i.e. has not shown the minimum effort and/or abilities to gain the respective knowledge and had not been allowed to complete the level.[6]

We will assume that disrtibution of the educational attainment of the employed is the same as the distribution pertaining to the population aged 15 or more, available from the Barro-Lee dataset. Thus, the human capital measure for the entire group of employed will be equal to:

$$H(t) = \sum_{i=1}^{4} H_i(t), \tag{7}$$

where $H_i(t)$ is the human capital of the i-th group having the respective educational attainment. The groups are:

1. Employed with no schooling or incomplete primary education; their corresponding human capital is:

$$H_1(t) = e^0 \cdot \theta_1(1) \cdot L(t) = \theta_1(t) \cdot L(t)$$

[6]Other reasons may also be present, such as lack of parental control and support during the respective course of education. However, such reasons do not invalidate the lack of effors and/or abilities argument, but complement or shed additional light on the environment that forms the characteristics of a person.

2. Employed with completed primary education or incomplete secondary education; their corresponding human capital is:

$$H_2(t) = e^{0.134 \cdot 4} \cdot \theta_2(t) \cdot L(t) = 1.71 \cdot \theta_2(t) \cdot L(t)$$

3. Employed with completed secondary education or incomplete post-secondary education; their corresponding human capital is:

$$H_3(t) = e^{0.134 \cdot 4 + 0.101 \cdot 4} \cdot \theta_3(t) \cdot L(t) = 2.56 \cdot \theta_3(t) \cdot L(t)$$

4. Employed with complete post-secondary education; their corresponding human capital is:

$$H_4(t) = e^{0.134 \cdot 4 + 0.101 \cdot 4 + 0.068 \cdot 4} \cdot \theta_4(t) \cdot L(t) = 3.36 \cdot \theta_4(t) \cdot L(t)$$

The coefficients $\theta_i(t)$ represent the share of employed persons having the respective educational level in total employment, with $\sum_{i=1}^{4} \theta_i = 1$. Note that in the calculations we assume that on average the completion of each educational level requires 4 years of study.

The results concerning the human capital stock[7] are presented in Table 3 in Appendix A.

3.3 Missing data on educational attainment

As already mentioned, there are in all three data points available for each country in the sample – for 1990, for 1995, and for 2000. The missing observations are

[7] From now on the term human capital stock will be used in the sense of human-capital-augmented labour force, as defined by equation (3) and the following labor categories definition.

calculated by linear interpolation. Although this technique may be considered too rough, here its usage is justified since educational systems are very conservative in general and no considerable deviations from trend in educational structure are expected for such short periods of time. Even if these calculations brought considerable bias into the data (which is highly doubtful) the results for the three available datapoints would remain valid since accounting is done year by year.

The data on educational attainment are presented in Tables 8 through 11 in Appendix A.

4 Comments on the results

The first thing that is noticed when looking at the graphs (see Figures 1 through 7 in Appendix B; see also Tables 5, 6 and 7 in Appendix A.) is that more or less total factor productivity is the major driving force of GDP growth. This is not surprising since all of the countries under consideration went through substantial restructuring of their economies. The opening towards the more developed West and the import of new technologies act as a serious push that boosts the productivity and the efficiency of those economies. And it cannot be otherwise in the face of serious competition of foreign companies. The import of knowledge is no less important for TFP growth. The foreign investors that entered the closed for decades economies introduced new organizational knowledge and a new managerial culture. The private ownership of the means of production began to tolerate increasingly less the lack of effort on behalf of the employees. The strive for profit increased the process of product diversification.

The increased productivity of the former socialist economies is something that is very little subject to dispute. However, the point of interest here is: to what

extent is total factor productivity influenced by the dynamics of the educational structure? The non-technical approach to the data (i.e. direct observation) shows that the employment dynamics is almost the same as the dynamics of the measure of human capital that we have adopted here. The minor discrepancies in the dynamics of the two variables mean that the augmentation of employment with human capital does not add much to the explanation of total factor productivity.

To put it also technically, we make use of equation (3) and the definition of employment categories:

$$H(t) = \sum_{i=1}^{4} e^{\phi_i(E)} \cdot \theta_i(t) \cdot L(t) = L(t) \cdot \sum_{i=1}^{4} e^{\phi_i(E)} \cdot \theta_i(t) \tag{8}$$

Differentiating the right-hand side with respect to time, we get:

$$\dot{H}(t) = \dot{L}(t) \cdot \sum_{i=1}^{4} e^{\phi_i(E)} \cdot \theta_i(t) + L(t) \cdot \sum_{i=1}^{4} \left(e^{\phi_i(E)} \cdot \dot{\theta}_i(t) \right) \tag{9}$$

Dividing equation (9) by equation (8), we obtain:

$$\frac{\dot{H}(t)}{H(t)} = \frac{\dot{L}(t)}{L(t)} + \frac{\sum_{i=1}^{4} e^{\phi_i(E)} \cdot \dot{\theta}_i(t)}{\sum_{i=1}^{4} e^{\phi_i(E)} \cdot \theta_i(t)} \tag{10}$$

When $\lim \dot{\theta}(t) \to 0$, then equation (10) reduces to:

$$\frac{\dot{H}(t)}{H(t)} = \frac{\dot{L}(t)}{L(t)}$$

Indeed, the thetas do not fluctuate significantly during the investigated period.[8] That is why the dynamics of the human-capital-augmented labor follows

[8] See Tables 8 through 11 in Appendix A.

closely the dynamics of employment[9], although the two are not exactly identical.

A first thought might be to blame the analytical frameworks used in the analysis. However, we should immediately recall that growth accounting has nothing to do with the dynamics of educational attainment, and also it by no means has interfered with the way the human-capital-augmented employment has been constructed. This comes to show that the problem in fact lies outside the methodological frameworks used. And of course, this cannot serve as an argument against theoretical findings.

A reasonable explanation of this deviation from what theory claims lies in the way by which the data concerning educational attainment, and consequntly human-capital-augmented employment, have been constructed. It is a fact that the quality of education varies over time, but this quality variation is by no means reflected in the data: all we have at hand is only years of schooling that weigh equally at different points in time. Also, we have educational structure of the population that changes very slowly (if at all). Educational systems, and consequently quality of education, are also affected by the process of transition and in turn affect the performance of the economy as a whole. Finding the weights of the schooling years at different points of time might bring a better explanation of growth than we have achieved in this study. To do this, multi-country comparative studies would be preferable in order to find some benchmarks to lean on. Only then, if the findings are not different from those in the current paper, challenges of some aspects of the theory might be sought.

[9]The differences in the dynamics of the two variables are shown in Table 4 in Appendix A.

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A Tables

Table 1: Physical capital stock, at 1995 prices

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1990	*NA*	8364	*NA*	896	291	8604	*NA*
1991	*NA*	8250	21056	894	286	8555	*NA*
1992	*NA*	8191	21028	893	283	8459	2978
1993	*NA*	8136	21023	894	281	8403	2976
1994	2314	8116	21148	898	281	8402	2971
1995	2333	8174	21216	911	282	8471	2966
1996	2322	8264	21356	934	285	8592	3004
1997	2289	8332	21600	971	287	8781	3068
1998	2288	8392	22005	1018	288	9021	3152
1999	2310	8432	22477	1069	289	9392	3186
2000	2352	8492	23046	1120	290	9750	3204

Source: Eurostat, Ameco database

Note: All data are in national currencies. For Bulgaria - in millions of BGN; for the Czech Rep. - in billions of CZK; for Hungary - in billions of HUF; for Poland - in billions of PLN; for Romania - in trillions of ROL; for Slovenia - in billions of SIT; for Slovakia - in billions of SKK

Table 2: Employment, 1000s

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1990	4097	*NA*	*NA*	*NA*	10840	*NA*	924
1991	3564	*NA*	*NA*	*NA*	10786	*NA*	874
1992	3274	*NA*	4085	15181	10458	*NA*	835
1993	3222	4874	3827	14894	10062	*NA*	819
1994	3242	4927	3752	14658	10012	2103	816
1995	3282	5174	3679	14791	9493	2147	912
1996	3286	5155	3648	14969	9379	2225	894
1997	3157	5167	3646	15177	9023	2206	875
1998	3153	5050	3698	15356	8813	2199	875
1999	3088	4842	3812	14757	8420	2132	888
2000	2980	4818	3849	14526	8629	2101	895

Sources: Eurostat, Ameco database

Table 3: Human-capital-augmented employment, 1000s

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1990	7737	*NA*	*NA*	*NA*	20302	*NA*	1588
1991	6748	*NA*	*NA*	*NA*	20197	*NA*	1509
1992	6214	*NA*	7251	28850	19579	*NA*	1450
1993	6131	8935	6775	28389	18834	*NA*	1431
1994	6185	9071	6624	28022	18736	3804	1433
1995	6278	9566	6480	28359	17762	3900	1610
1996	6313	9571	6463	28801	17589	4058	1584
1997	6093	9631	6498	29304	16959	4039	1558
1998	6110	9451	6629	29753	16602	4042	1565
1999	6010	9097	6872	28693	15898	3936	1594
2000	5825	9089	6980	28343	16331	3894	1614

Sources: Eurostat, Ameco database
Own calculations

Table 4: Difference between growth rates of human capital and employment

Year	Bulgaria	Czech rep.	Hungary	Poland	Romania	Slovakia	Slovenia
1991	0.0022	NA	NA	NA	-0.0002	NA	0.0051
1992	0.0024	NA	NA	NA	-0.0002	NA	0.0051
1993	0.0025	NA	-0.0024	0.0029	-0.0002	NA	0.0052
1994	0.0026	0.0043	-0.0025	0.0029	-0.0002	NA	0.0053
1995	0.0026	0.0045	-0.0025	0.0030	-0.0002	0.0044	0.0059
1996	0.0044	0.0040	0.0059	0.0036	0.0023	0.0042	0.0043
1997	0.0042	0.0040	0.0059	0.0036	0.0022	0.0040	0.0043
1998	0.0043	0.0039	0.0059	0.0035	0.0022	0.0040	0.0044
1999	0.0042	0.0038	0.0060	0.0034	0.0022	0.0039	0.0044
2000	0.0042	0.0040	0.0059	0.0034	0.0023	0.0039	0.0044

Source: Own calculations

Table 5: GDP growth rates, %

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1991	−7.25%	−11.60%	−11.60%	−7.03%	−13.08%	−8.90%	7.17%
1992	−1.48%	−0.50%	−0.50%	2.51%	−8.73%	−5.46%	6.22%
1993	1.81%	0.10%	0.10%	3.76%	1.52%	2.84%	5.84%
1994	2.86%	2.20%	2.20%	5.26%	3.94%	5.33%	6.14%
1995	−9.39%	5.90%	5.90%	6.98%	7.14%	4.11%	4.62%
1996	−5.37%	4.20%	4.20%	5.98%	3.94%	3.64%	4.20%
1997	3.90%	−0.70%	−0.70%	6.81%	−6.05%	4.76%	1.47%
1998	2.35%	−1.10%	−1.10%	4.80%	−4.81%	3.56%	2.04%
1999	5.38%	1.20%	1.20%	4.09%	−1.15%	5.55%	3.78%
2000	4.08%	3.90%	3.90%	3.96%	2.14%	3.89%	4.62%

Source: Eurostat, Ameco database

Table 6: TFP growth rates, raw labor used

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1991	*NA*	*NA*	*NA*	*NA*	−12.23%	−5.05%	*NA*
1992	*NA*	*NA*	*NA*	*NA*	−6.31%	−2.10%	*NA*
1993	*NA*	*NA*	2.14%	5.01%	4.31%	4.28%	*NA*
1994	*NA*	1.57%	0.53%	6.15%	4.23%	5.59%	*NA*
1995	1.76%	2.34%	4.09%	5.91%	10.45%	−4.06%	4.49%
1996	−9.32%	4.03%	1.84%	4.33%	4.49%	4.54%	3.28%
1997	−2.29%	−1.15%	0.97%	4.58%	−3.78%	5.44%	4.50%
1998	4.02%	0.13%	3.00%	2.41%	−3.40%	2.66%	3.52%
1999	3.40%	3.82%	2.09%	5.05%	1.79%	3.23%	3.14%
2000	7.12%	3.98%	2.66%	3.42%	0.33%	2.10%	2.82%

Sources: Eurostat, Ameco database
Own calculations

Table 7: TFP growth rates, human-capital-augmented labor used

Year	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovenia	Slovakia
1991	*NA*	*NA*	*NA*	*NA*	−12.21%	−5.39%	*NA*
1992	*NA*	*NA*	*NA*	*NA*	−6.30%	−2.44%	*NA*
1993	*NA*	*NA*	2.30%	4.81%	4.33%	3.93%	*NA*
1994	*NA*	1.28%	0.70%	5.96%	4.24%	5.23%	*NA*
1995	1.59%	2.04%	4.26%	5.71%	10.47%	−4.46%	4.20%
1996	−9.61%	3.76%	1.45%	4.09%	4.34%	4.25%	3.00%
1997	−2.57%	−1.42%	0.58%	4.34%	−3.93%	5.15%	4.23%
1998	3.73%	−0.13%	2.61%	2.18%	−3.55%	2.37%	3.25%
1999	3.12%	3.56%	1.69%	4.82%	1.64%	2.94%	2.89%
2000	6.84%	3.71%	2.27%	3.19%	0.17%	1.81%	2.56%

Sources: Eurostat, Ameco database
Own calculations

Table 8: $\theta_1(t)$, %

Year	Bulgaria	Czech	Hungary	Poland	Romania	Slovakia	Slovenia
1990	15.3	21	21.9	6.1	16.9	24.4	29.4
1991	15.62	20.9	23.38	6.2	17	24.24	29.54
1992	15.94	20.8	24.86	6.3	17.1	24.08	29.68
1993	16.26	20.7	26.34	6.4	17.2	23.92	29.82
1994	16.58	20.6	27.82	6.5	17.3	23.76	29.96
1995	16.9	20.5	29.3	6.6	17.4	23.6	30.1
1996	16.82	20.34	28.86	6.54	17.38	23.32	29.84
1997	16.74	20.18	28.42	6.48	17.36	23.04	29.58
1998	16.66	20.02	27.98	6.42	17.34	22.76	29.32
1999	16.58	19.86	27.54	6.36	17.32	22.48	29.06
2000	16.5	19.7	27.1	6.3	17.3	22.2	28.8

Source: Own calculations

Table 9: $\theta_2(t)$, %

Year	Bulgaria	Czech	Hungary	Poland	Romania	Slovakia	Slovenia
1990	58.9	51.1	58.2	71.2	52.9	49.6	45.9
1991	58.12	51.12	56.18	70.6	52.84	49.64	45.74
1992	57.34	51.14	54.16	70	52.78	49.68	45.58
1993	56.56	51.16	52.14	69.4	52.72	49.72	45.42
1994	55.78	51.18	50.12	68.8	52.66	49.76	45.26
1995	55	51.2	48.1	68.2	52.6	49.8	45.1
1996	54.58	50.86	48.04	67.68	52.4	49.64	44.84
1997	54.16	50.52	47.98	67.16	52.2	49.48	44.58
1998	53.74	50.18	47.92	66.64	52	49.32	44.32
1999	53.32	49.84	47.86	66.12	51.8	49.16	44.06
2000	52.9	49.5	47.8	65.6	51.6	49	43.8

Source: Own calculations

Table 10: $\theta_3(t)$, %

Year	Bulgaria	Czech	Hungary	Poland	Romania	Slovakia	Slovenia
1990	16.9	21.8	12.8	18.6	26.5	19.7	17.9
1991	17.0	22.0	13.1	18.9	26.5	19.9	17.9
1992	17.2	22.2	13.4	19.2	26.4	20.1	17.9
1993	17.3	22.4	13.6	19.6	26.4	20.2	18.0
1994	17.5	22.6	13.9	19.9	26.3	20.4	18.0
1995	17.6	22.8	14.2	20.2	26.3	20.6	18.0
1996	17.7	23.0	14.4	20.5	26.3	20.8	18.2
1997	17.9	23.3	14.6	20.8	26.3	21.1	18.3
1998	18.0	23.5	14.8	21.2	26.4	21.3	18.5
1999	18.2	23.8	15.0	21.5	26.4	21.6	18.6
2000	18.3	24.0	15.2	21.8	26.4	21.8	18.8

Source: Own calculations

Table 11: $\theta_4(t)$, %

Year	Bulgaria	Czech	Hungary	Poland	Romania	Slovakia	Slovenia
1990	8.8	5.0	7.2	4.0	3.6	5.4	5.4
1991	9.1	5.1	7.4	4.2	3.6	5.5	5.7
1992	9.5	5.2	7.7	4.4	3.6	5.6	6.0
1993	9.8	5.3	7.9	4.6	3.7	5.8	6.3
1994	10.2	5.4	8.2	4.8	3.7	5.9	6.6
1995	10.5	5.5	8.4	5.0	3.7	6.0	6.9
1996	10.9	5.8	8.7	5.2	3.9	6.2	7.2
1997	11.3	6.0	9.0	5.5	4.1	6.4	7.5
1998	11.6	6.3	9.4	5.7	4.4	6.6	7.9
1999	12.0	6.5	9.7	6.0	4.6	6.8	8.2
2000	12.4	6.8	10.0	6.2	4.8	7.0	8.5

Source: Own calculations

B Graphs

In the following graphs, GDP means gross domestic product, TFP1 is total factor productivity, obtained using raw employment figures, and TFP2 is total factor productivity, obtained using human-capital-augmented employment.

Figure 1: Bulgaria: Growth rates of real GDP and TFP, %

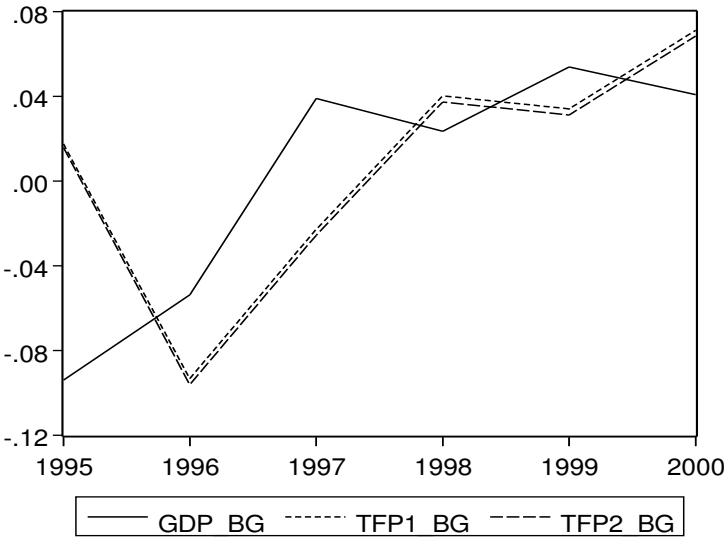

Figure 2: Czech Republic: Growth rates of real GDP and TFP, %

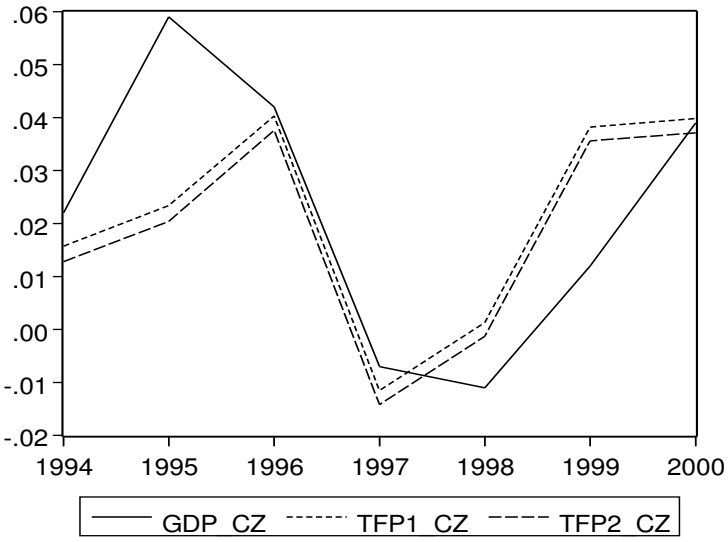

Figure 3: Hungary: Growth rates of real GDP and TFP, %

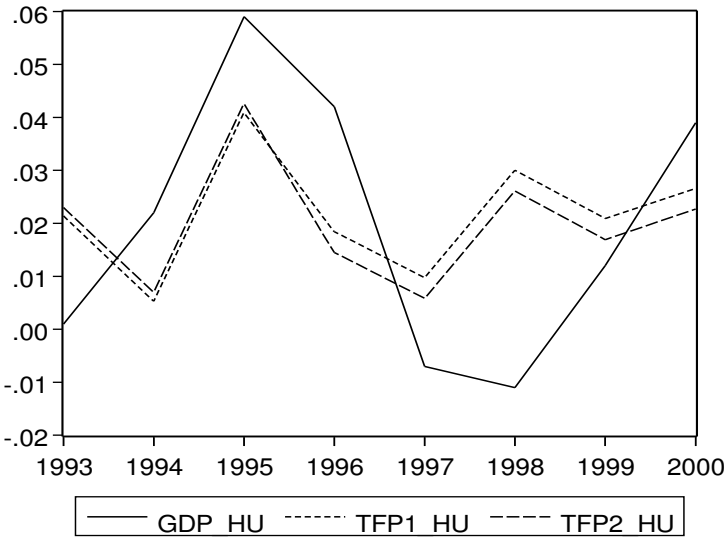

Figure 4: Poland: Growth rates of real GDP and TFP, %

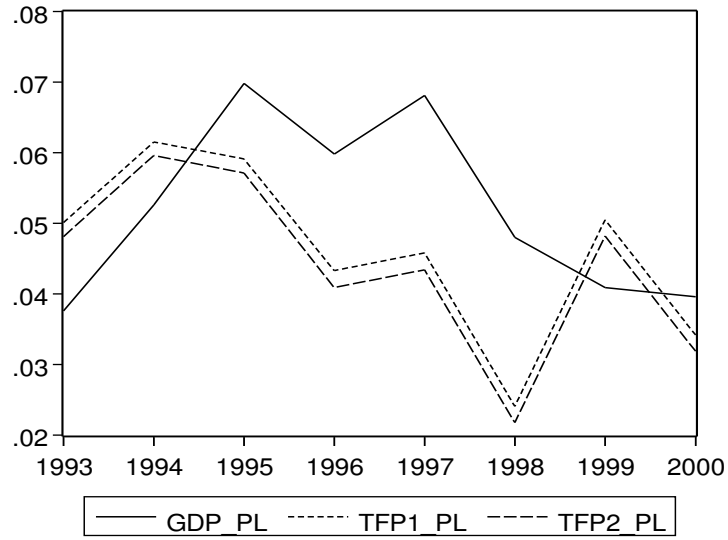

Figure 5: Romania: Growth rates of real GDP and TFP, %

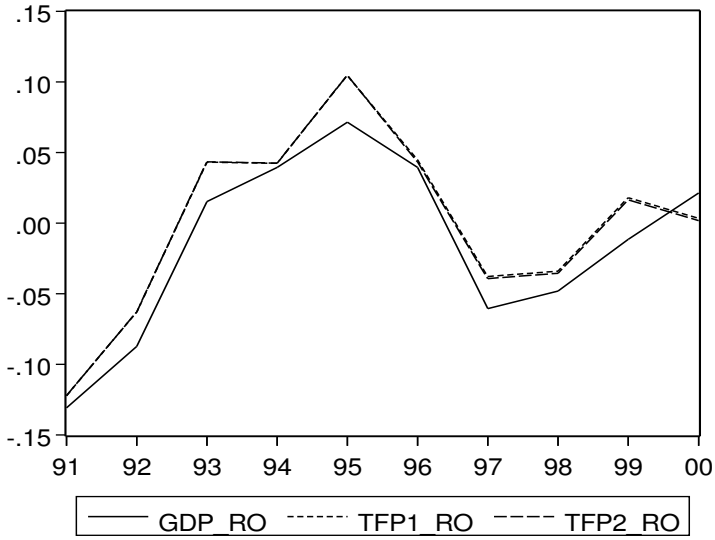

Figure 6: Sovenia: Growth rates of real GDP and TFP, %

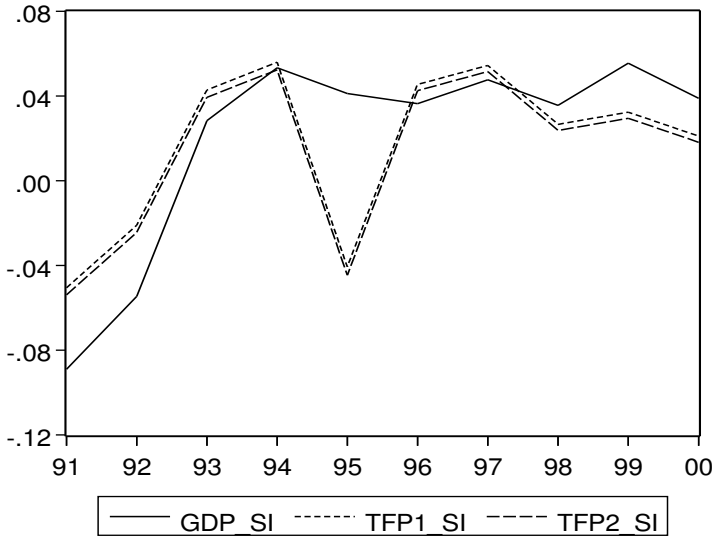

Figure 7: Slovakia: Growth rates of real GDP and TFP, %